Synthesis and Characterization of Graphene Oxide Nanocomposite for Electrochemical Energy Applications

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Introduction

Graphene is composed of sp^2-hybridized carbon atoms hexagonally arranged in a two-dimensional structure, resulting in a large surface area on both sides of the planar axis [1]. Materials of the graphene family include few-layer graphene, graphene oxide (GO), graphene nanosheets and reduced graphene oxide [2]. Compared with carbon nanotubes, graphene-based materials can provide a larger surface area and better dispersibility in most solvents [3]. Because of the formation of hydrogen bonds between polar functional groups on the GO surface and water molecules, a stable GO colloidal suspension can be attained, suggesting advantages for potential biomedical applications of GO compared with other carbon-based materials. Graphene have been used in diverse nanobiotechnological applications such as in the environment, biomedicine, biotechnology, sensors, actuators, energy storage devices, photovoltaic and opto-electronics [4,5]. In the recent discovery of single-layer graphene which was isolated from graphite has attracted extensive interests because of their physical properties. Graphene has demonstrated a variety of excellent properties such as the world's mechanical strongest material: the specific strength of graphene is 48000 kN mkg^{-1}, which is over 300 times higher than the specific strength of steel (steel specific strength = 154 kN mkg^{-1}), extremely lightweight and high thermal conductivity, the electrical conductivity of graphene is approximately 3000 WmK^{-1} compared to ~400 WmK^{-1} the copper. High electron mobility at room temperature (250000 cm^2/Vs) and the ability to sustain extremely high densities of electric current and superior mechanical properties with Young's modulus of 1 TPa [6-7]. Moreover, there are some potential applications including the single molecule gas detection, transparent conducting electrodes, composites and energy storage devices such as supercapacitors [8-9]. Due to these outstanding properties, graphene is expected to have a profound impact on applications such as electronic devices [10], nanocomposites [11] and energy

storage. So, the developments of graphene composites have shown the great potential for improving the strength of matrix. Readily chemically functionalized; making the material very versatile and allowing graphene to be incorporated into a range of devices and materials to suit the intended application.

Graphene oxide

Graphene oxide (GO) is useful and promising material for graphene-based applications in electronic, optics, chemistry, energy storage and biology. At the beginning of graphene history GO was only a simple and cheap step for preparation of single and multilayer graphene films and bulk structures by reduction. The further studies revealed the substantial structure imperfection of GO derived materials due to the defects in initial graphite and incompletion of reducing process. However, the results of recent research demonstrated a great amount of unique chemical, optical and electronic properties of GO that allow regarding it as independent nanomaterial possessing a large area of applications. In general, it represents the ultra-large organic molecule containing 2D carbon mesh. Unlike conventional graphene it provides wide range of chemical methods for attachment of various functional groups to its surface for control optical transparency, electrical and thermal conductance. Recently developed methods for preparation of GO derivatives saturated by carboxyl groups open the new attractive application areas in green technologies including energy storage and utilizing nuclear wastes [12]. This technique is established on enhancing the oxidation degree of GO by breaking the aromatic sp^2 hybridization into sp^3. The structure of GO consists of two parts: the aromatic matrices and the oxygen-consisting groups. The tuning of band gap on the account of oxidation from the graphene surface increase the potential applications of GO in the field of optoelectronics, sensors, transparent electrode and Li-ion battery [13]. GO reduction by chemical methods results in the formation of limited solubility or even irreversible

agglomerates of reduced graphene oxide (rGO) during preparation in water and most organic solvents (unless capping reagents are used) because of the strong π–π stacking tendency between rGO sheets. Agglomeration of rGO can be limited by attaching other molecules or metal oxide to the sheets. The most commonly used chemical reducing agents are hydrous hydrazine, hydrazine monohydrate and hydrogen sulfide, which are highly toxic to living organisms and the environment [14]. Reduced graphene oxide (rGO) is a 2D carbon material and is packed in a honeycomb crystal lattice. Numerous methods have been used in the synthesis of rGO, such as chemical, thermal, microwave and microbial/bacterial. Chemical exfoliation is preferable due to its large-scale production and low cost. Chemical exfoliation involves three steps, oxidation of graphite powder, dispersion of graphite to graphene oxide (GO) and GO reduction to produced reduced graphene oxide (rGO). RGO has been widely applied in energy storage devices, photovoltaics devices, electrochemical sensor corrosion protection, and lubricants. This is due to its unique properties, such as high conductivity, chemical stability, high surface area and high electron mobility [15].

Graphene quantum dots (GQDs) have a single or few layered graphene-like structures, which is mainly composed of sp^2 hybridized carbon atoms in inner and sp^3 hybridized carbon-oxygen bonds outside, including hydroxyl, carboxyl and epoxy groups. The intrinsic fluorescence emission of GQDs is resulted from the π-π* transition of the internal hybrid sp^2 region, which controls the width of band gap of the GQDs [16]. Meanwhile, the surface oxygen groups also participate in the formation of the energy level structure, leading to multiple surface state energy levels and corresponding to n-π* transitions under proper irradiation [17]. The fluorescence emission caused by n-π* transitions was usually referred to extrinsic emission [18]. Fluorescent carbon materials like GQDs and carbon dots (CDs) are usually derived from various precursors like graphene oxide,

graphite and other carbonaceous materials. Fluorescence properties associated with that of zero dimensional GQDs arise mainly from the quantum confinement, edge effect, surface passivation and also depend on the method employed for their preparation. In general, it is possible to tune the optical properties and band gap of these materials by using chemical reduction methods [19-20]. Subsequently, these synthetic methods offer additional advantages in terms of obtaining GQDs possessing a large optical absorptive, chemical stability, adequate biocompatibility as well as low toxicity. Thus, GQDs distinguish themselves from other traditional fluorescent materials due to these intrinsic superior properties and making them an ideal candidate for a wide variety of applications including bio-imaging, medical diagnosis, catalysis, photovoltaic devices [21].

Reduced graphene quantum dots

Recently, graphene-based semiconductor nanoparticles (NPs) also termed reduced graphene quantum dots (rGQDs) they have attracted more attention as a new type of luminescent NPs because of their remarkable electrical conductivity and electrochemical properties are suitable to use in various potential applications such as photo catalysis, solar cell, biosensor, bio imaging, and opto-electronic properties [22].

Graphene quantum dots (GQDs) and reduced graphene quantum dots (rGQDs) are the fragments of graphene comprising single or few layers of graphene with size in the range of 3–10 nm. From literature review, it is reported that the various sized rGQDs with different photo luminescent colors ranging from the visible to near-infrared region [23]. Interestingly, it is observed that yield of rGQDs under white light is much significant than that from GQDs and it demonstrate the reduction of rGQDs with hydrazine hydrate found to be decreasing the band gap which attributes to improved inter-intra band electron transition and fluorescence properties of rGQDs [19]. It depends upon the quantum confinement, edge effect, surface passivation and also on the synthesis

method. So, it can be improving the emission color by controlling the irradiation time and the precursors used [24]. It can also interpret that the PL is associated with the $\pi^* \rightarrow n$ transition of electrons and observed quantum confinement is ascribed to the change the size of sp^2 domains, which leads to a change in the π-π^* energy gap; the n-state levels remain unaffected by the change in size [25]. Although optical and structural properties of rGQDs have been studied extensively, and also describing the effects of 365 nm UV-irradiation or high-pressure mercury lamp providing only a partial insight change their physical and chemistry of the rGQDs. This UV-irradiated modified rGQDs has utilizing for the purpose of UV detection on the basis of UV-induced optical changes and other sensing property. The optical response improved rGQDs is successfully utilized as a photocurrent generation layer in a novel UV-irradiation [26]. However, for instance the rGQDs prepared from glucose via acidic oxidation were functionalized with hydroxyl, carbonyl, and carboxylic acid containing oxygen groups. Various chemical and physical techniques have been reported. The supercapacitors are classified into two classes;

1. Electrical double layer capacitor (EDLC).
2. Pseudocapacitors.

These are characterized by its unique mechanism of charge storage. EDLC stores the charge electrostatically or non-faradaically, i.e. charges accumulate on the surface of the electrode. In this process, charge separation takes place between the electrode and the electrolyte interface. Usually, carbon-based materials such as activated carbon, graphene, carbon nanotube, metal oxide were used in EDLCs. In pseudocapacitor, the charge storage happens faradaically, and the transfer of charges takes place between electrode and electrolyte. This Faradic mechanism might allow pseudocapacitors to attain maximum capacitance and energy density than that of EDLC. The GO

and metal oxide composites show excellent electrical conductivity, specific capacitance and charging/discharging process for supercapacitor applications.

Among the library of various metal oxides, cobalt oxide (Co_3O_4) emerged as a shining star on the horizon of metal oxides. It has high surface to volume ratio, simple preparation method, outstanding chemical durability, promising ratio of surface atoms and diverse morphology, which makes it more prominent in the family of metal oxides. However, the practical applications of these metal oxides based pseudocapacitors may still be bounded due to sluggish electron kinetics and rapid capacity decay arising from highly corrosive electrolyte and the easily damaged morphologies of the materials during the faradic reactions [27].

Recently, graphene-based composite material decorated with metal oxide nanoparticle such has RuO_2, CeO_2, MnO_2, Mn_3O_4, have been extensively explored as electrode material in sensor application. A short survey in the literature indicates that considerable research has been concentrated on the use of low-cost nanoscale metal-oxide material such as Co_3O_4 [28], for the preparation of supercapacitor and nonenzymatic glucose sensors application. Because of the extremely reduced sized, large surface-to-volume ratio, greater level of crystallinity and the Debye length comparable to its dimensions, nanostructure metal oxides could greatly enhance sensitivity and selectivity of the related sensors [29].

Activated carbon/metal oxide composite

Activated carbon is a porous carbonaceous material with the highly developed surface area and rich surface groups, are widely used in numerous applications, including adsorption, catalyst sup port, gas separation and storage, solvent recovery and decolorizing, supercapacitors and as electrodes. The internal porosity and their related properties such as surface area, pore volume, pore size distribution, and the presence of functional groups on pore surfaces play a significant

role in the adsorptive capacities of activated carbons. Activated carbons with abundance of micropores are extensively used for adsorption of small molecule pollutants and highly developed mesoporous activated carbons are used for the adsorption of larger molecules such as dyes. The factors such as the nature of raw materials, the activation method, the activating agent and the conditions of activation process affect the textural and chemical characteristics of the activated carbons. In recent years, activated carbon is being produced from a large number of easily available and low-cost materials such as agricultural products like paulownia wood, vine shoots, fire wood, marigold straw, candlenut shell, corncob, coconut shells, reedy grass leaves, lotus stalks and burrito shells.

Activated carbons are usually produced by two methods:

(i) Physical activation.

(ii) Chemical activation.

Physical activation includes carbonization of the precursor in an inert atmosphere and activation of the resulting char by an activation agent such as steam, CO_2 or air [30]. The carbonization step consists of a procedure, in which, volatile compounds are released due to several complex, rival, and consecutive reactions leading to the achievement of fixed carbon in an inert atmosphere and at temperature range of 400 to 500 ^oC. In the second step of the physical activation process, the precursor is placed under a heat treatment at high temperatures from 700 to 1100 ^oC in the presence of oxidizing agents, such as CO_2, water steam, air, or a mixture of them [31]. In chemical activation process, the precursor is mixed with a certain amount of active agents such as SnO_2, TiO_2, Zn, KOH, NaOH, H_3PO_4 and $ZnCl_2$, which lead to the development of porous structures in the material. Among the various dehydrating agents used for chemical activation, phosphoric acid is preferred recently due to environmental and economic concerns [32]. Among them, SnO_2, TiO_2

and Zn are the most researched n-type semiconductor materials because of their importance in energy storage devices. Zn has attracted considerable attention because of its environmental friendliness, good electrochemical activity and wide-band-gap (3.37 eV). With unique electrical properties as an n-type semiconductor with a wide-band-gap of 3.6 eV, SnO_2 has received enormous attention. It has a wide scope of uses in dye-based solar cells, optoelectronic devices, gas sensors, catalysts, energy storage devices, and electrode materials. Nanocomposites of SnO_2, TiO_2 and Zn can improve the properties of materials because of synergistic enhancement [33].

Recently, carbon nanofibers, carbon nano-onions, graphene, carbon nanotubes, and activated carbon have been studied as carbon-based materials for supercapacitor electrodes. Among them, researchers mostly use activated carbon because of its large surface area [34].

Aims and objective of the present study

The present study focused on the supercapacitor's applications of graphene oxide with different metal oxides composite. The main aim of this work is to study the modifications in the graphene oxide/metal oxide nanocomposites for energy storage applications. Aims and objectives of this research work is proposed as follows,

- The 365 nm UV-source irradiated glucose used as a precursor to synthesis the rGQDs with help of microwave assisted hydrothermal method.
- To synthesize different nanocomposite by the Hummer's and hydrothermal method.
    i. Graphene oxide incorporated with cobalt oxide Polyhedron Structured nanocomposite
    ii. Activated carbon/graphene oxide/Tin oxide and Activated carbon/graphene oxide/Titanium Dioxide-Zinc acetated hydroxide nanocomposite.

- To know chemical interaction, structural phase, surface morphology and particle size of the compound. The graphene oxide and different metal oxide composites are characterized by X-ray diffraction (XRD), Raman spectra, UV-Vis spectroscopy, Photoluminescence spectroscopy (PL), Fourier transform infrared (FTIR) spectroscopy, Atomic force microscopy (AFM), Field emission scanning electron microscope (FESEM), High resolution transmission electron microscopy (HRTEM) and dielectric constant.
- To fabrication of the different kind of supercapacitor such as flexible, high-energy density all-solid-stated symmetric supercapacitor (SSC), asymmetric supercapacitor (ASC) and also for electrochemical glucose sensor. Electrochemical performance examined by using a cyclic voltammetry (CV), Linear sweep voltammetry (LSV), charging-discharging (GCD) and electron impedance spectroscopy (EIS).

The brief sketch of the proposed thesis

Thesis contains six chapters; the first chapter includes the introductions of graphene oxide, reduced graphene oxide, reduced graphene quantum dots and metal oxide their physical and chemical properties and applications. The aims and objective of the work and literature review are discussed. The second chapter deals with various techniques involved such as synthesis, characterization, fabrication, and electrochemical measurement. The third to sixth chapters discuss on the results and analysis of experiments carried out to meet the research objectives. The third chapter includes the Graphene oxide/cobalt oxide nanocomposite for high-performance electrode for supercapacitor application. The fourth chapter contains synthesis of activated carbon incorporated with graphene oxide/Tin oxide and graphene oxide/Titanium dioxide-zinc acetated hydroxide nanocomposite for supercapacitor application. The fifth chapter focuses on the Polyhedron structured graphene oxide/cobalt oxide nanocomposite for electrochemical sensor application. The

sixth chapter contain UV-irradiated hydrothermal synthesis of reduced graphene quantum dots for electrochemical applications. The summary and epilogue are presented in the seventh chapter followed by the section namely the references and list of research publication.

Chapter I: Introduction

The first chapter describes the brief information of the graphene oxide, graphene quantum dots, reduced graphene oxide, and metal oxide composite and their physical properties, and industrial applications. Literature review of the previously reported results.

Chapter II: Synthesis and Characterization Techniques

The second chapter provide the synthesis methods like Hummer's and hydrothermal used. And also elaborated the various characterization techniques to analyze the chemical change, surface morphology, elemental composition, electrical conductivity, optical properties and electrochemical measurement.

Chapter-III: Graphene oxide/cobalt oxide nanocomposite for high-performance electrode for supercapacitor application

This chapter discuss a graphene oxide/Cobalt oxide (GO/Co_3O_4) nanocomposite was synthesized by varying weight ratio of Co_3O_4 through a simple hydrothermal method and derived nanocomposite have emerged as promising candidates for applications in renewable energy storage/conversion device. They are known to exhibit large specific surface area, high electrical conductivity, good chemical stability, high mechanical strength and flexibility, when performing structural, morphological, chemical compositional and surface area/pore-size distribution analysis. Fabricated GO/Co_3O_4 nanocomposite electrode was performed with PVA/KOH gel electrolyte as separator and examined the supercapacitor performance. As an outcome, the maximum specific capacitance (C_{sp}) achieved by the GO/Co_3O_4-5 electrode is of 1012 Fg^{-1} at current density (CD) of

2 Ag^{-1}. The assembled GO/Co_3O_4-5 electrode supercapacitor device retains the energy density of 18.9 $Whkg^{-1}$ with a high-power density of 1364.8 Wkg^{-1}. It observed the coulombic efficiency is 96.9 % and capacitance retention is 70.3 % even after 4000 cycles. These results demonstrate that GO/Co_3O_4 nanocomposite material is highly prominent material for supercapacitor application.

Chapter –IV: Activated carbon incorporated graphene oxide with SnO_2 and TiO_2-Zn nanocomposite for supercapacitor application

This chapter discusses the incorporated a sample of activated carbon/graphene oxide/tin oxide (AC/GO/SnO_2) and activated carbon/graphene oxide/titanium-zinc acetate dehydrate (AC/GO/TiO_2-Zn) nanocomposite synthesized by hydrothermal method. The characterization techniques such as X-ray diffraction (XRD), Fourier transform infrared (FT-IR) spectroscopy, UV-Vis absorption spectroscopy, field emission scanning electron microscopy (FESEM) and high-resolution transmission electron microscopy (HR-TEM) were used to know the structural phase change, morphology and microstructural arrangement of AC/GO/SnO_2 and AC/GO/TiO_2-Zn nanocomposites. The supercapacitor device was fabricated using nanocomposite AC/GO/SnO_2 and AC/GO/TiO_2-Zn electrode. The electrochemical properties of the fabricated nanocomposite electrode and the fabricated supercapacitor were characterized using cyclic voltammetry (CV), galvanostatic charging-discharge (GCD) and electrochemical impedance spectroscopy (EIS) techniques using 3 M KOH gel electrolytes. The AC/GO/TiO_2-Zn electrode showed a maximum specific capacity of 1491.6 Fg^{-1} at a current density of 2.5 Ag^{-1} and a cycle stability of the capacity retention of 66.50% even after 10000 cycles. This result shows that the AC/GO/TiO_2-Zn is an electrode material with good electrochemical reversibility cycle life for supercapacitor applications.

Chapter-V: Synthesis and Characterization of Polyhedron Structured Graphene Oxide /Cobalt oxide Nanocomposite for Electrochemical Sensor Application

This chapter discuss the fabrication of a highly sensitive electrochemical sensor of novel material graphene oxide/cobalt oxide (GO/Co_3O_4) nanocomposites (NCs), and it was synthesized by using hydrothermal method and pure graphene oxide (GO) was extracted from raw graphite using Hummer's method. The fabricated NCs sensor was used to examine the glucose sensitivity at different concentrations. The structure phase, optical property and microstructural morphology characterizations was carried out with the help of X-ray diffraction (XRD), Raman spectroscopy, UV-Vis absorption spectroscopy, Field Emission Scanning Electron Microscopy (FESEM) and High-Resolution Transmission Electron Microscopy (HR-TEM) techniques respectively. The glucose sensitivity result shows good electrocatalytic activity for the oxidation of glucose in phosphate buffer (PBS) at pH 7.2. It is also seen that the oxidation peak current was linearly increased with the concentration of glucose in the range of 3 μM to 15 μM. The detection limit of glucose was estimated value is 1.12 μM and 1.33 μM, with (S/N=3). The fabricated modified electrode exhibits display an excellent interface ability species and metal ions with good stability and reproducibility. Obtained results suggesting that the developed sensor is a prominent candidature for the target analytes in real samples with satisfactory efficiency.

Chapter VI: Hydrothermal Synthesis of Reduced Graphene Quantum Dots from UV-Irradiated Glucose for Electrochemical Applications

This chapter discuss the structural and electrochemical properties of graphene quantum dots (GQDs) and reduced graphene quantum dots (rGQDs). The synthesis of rGQDs by using 365 nm UV-source irradiated glucose precursor with help of microwave assisted hydrothermal reaction. The modification in chemical interaction was studied by Fourier Transforms Infrared (FT-IR)

spectroscopy, and X-ray diffraction (XRD) confirms the structural change due to UV-irradiation effects. The Raman spectra confirms change in the intensity ratio of G and D band, and UV-Visible absorption peak of GQDs observed at 243, 245, 248 and 262 nm for 24, 48, and 72 hours UV-irradiated modified rGQDs. Transmission electron microscopy (TEM) images shows reduced the size with increasing UV-irradiation time which confirms the rGQDs. Atomic force microscopy (AFM) employed to know topological surface study. The electrochemical performance of cyclic voltammetry from a typical rectangular shape of the integral area suggesting it is exhibits strong electrochemical activity and specific capacity behaviour by redox reaction at different scan rate from 100 to 500 mV/s for GQDs and rGQDs. The current-voltage plot exhibited a gradual increase in current with applied voltage as well as irradiation at different hours. life electrode material for supercapacitor application.

Chapter-VII: Summary and Scope for Future Work

Summarizes the findings of the present investigation and the scope for further studies in this filed.

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List of Journal Publications:

1. A paper entitled "UV-irradiated hydrothermal synthesis of reduced graphene quantum dots for electrochemical applications. In ***Diamond and Related Materials,*** 114 (2021)108289. **(IF 3.80)** https://doi.org/10.1016/j.matpr.2020.08.367
   Veeresh S, Ganesh H, Nagaraju Y. S, Vandana M, Ashokkumar S. P, Vijeth H, Devendrappa H*.
2. A paper entitled "Graphene oxide/cobalt oxide nanocomposite for high-performance electrode for supercapacitor application" In ***Journal of Energy Storage,*** 52 (2022) 104715. (**IF 8.901**) https://doi.org/10.1016/j.est.2022.104715
   Veeresh S, Ganesha H, Nagaraju Y S, Vijeth H, Vandana M, Basappa M, Devendrappa H*
3. A paper entitled "Activated carbon incorporated graphene oxide with SnO2 and TiO2-Zn nanocomposite for supercapacitor application" In **Sustainable Energy & Fuels,** Communication Manuscript ID is : **SE-ART-08-2022-001178.**
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4. A paper entitled "UV-irradiation induced synthesis of reduced graphene quantum dots". In ***Materials Today:Proceedings,*** 45 (2021) 3968-3970.
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5. A paper entitled "Structure, morphology and optical properties of graphene oxide". *In **AIP Conference Proceedings,*** 2244 (2020) 080023, https://doi.org/10.1063/5.0009205
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14. A paper entitled "Single crystalline hierarchical SnO_2 microsphere and fluoride-mediated hollow structures for photocatalytic activity". In ***Materials Today: Proceedings,*** 45 (2021)3833-3836.
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15. A paper entitled "Synthesis of nanorod structured polyaniline nanofiber for high electrochemical efficiency". In ***AIP Conference Proceedings,*** 2244 (2020) 080025. https://doi.org/10.1063/5.0009207
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16. A paper entitled "Hydrothermal synthesis of highly crystalline NiO doped ZnO hexagonal shape nanorods arrays as cathode material for photocatalytic activities". In ***AIP Conference Series,*** 2265 (2020) 030136.
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18. A paper entitled "To study the synthesis and characterization of ZnO hexagonal nano cubes with hydrothermal growth and formation mechanism**". In *AIP Conference Proceedings,*** 2244 (2020) 080021.
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20. A paper entitled "Structure and optical band gap study of electrochemically synthesized polyaniline/ZnO nanocomposite for energy storage devices". In ***AIP Conference Proceedings***, 2244 (2020) 080027. https://doi.org/10.1063/5.0009210
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21. A paper entitled "Structure, morphology and optical properties of CuO nano particles immersed PANI/Li composite". In ***AIP Conference Proceedings,*** 2244 (2020) 080016. https://doi.org/10.1063/5.0009090
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22. A paper entitled "Cyclic voltammetry, morphology and thermal studies of electrochemically synthesized PANI/CuO nanocomposite for supercapacitor application". In ***AIP Conference Proceedings***, 2244 (2020) 080026.

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23. A Paper entitle "Preparation, Characterization and electrochemical properties of PEO/PVDF blend films" **In Chem. Phy.Lett.** 799 (2022) 139609. https://doi.org/10.1016/j.cplett.2022.139609
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24. A Paper entitle "Low cost synthesis and characterization of Donor P3HT Polymer for Fabrication of Organic Solar Cell" ***In IOP Conf. Ser.: Mater. Sci. Eng.*** 1221 (2022) 012060. Doi:10.1088/1757-899X/1221/1/012060
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25. A Paper entitle "Investigate the Optical, Structural and electrochemical properties of PVC/PMMA/NiO blend films" ***In IOP Conf. Ser.: Mater. Sci. Eng.*** 1221 (2022) 012059. Doi:10.1088/1757-899X/1221/1/012059
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Foreign visit:

Participated &presented an article entitled "Structural, Morphological characterization of Nitric acid and Potassium hydroxide/Activated carbon composite" organized by Institute of Engineering Research 4th ICASETM-21 International Conference held at **Holiday Inn Bur Dubai, UEA.** During December 29th to 30th 2021.
Veeresh S, Ganesha H, Nagaraju Y.S, Basappa M, Vijeth H, Devendrappa H*

Conference/Workshop attended:

1. Participated in the Capacity Building Workshop on "The future of Higher Education: Opportunities and Challenges" organized by Mangalore University, on May 18th 2019.

2. Participated and presented a paper entitled "Structure, morphology and optical properties of graphene oxide" in ICPN-2019 organized by Department of Physics at Mangalore University, on September 19th to 21th 2019.

3. Participated in the "Basic Training Program in Nano Science and Technology" organized by the Center for nano Science and Engineering, IISc Bangalore, on October 14th to16th 2019.
4. Participated and presented a paper entitled "UV-Irradiation Induced Synthesis of Reduced Graphene Quantum Dots" in ICNAN-2019 organized by the Center for Nanotechnology research (CNR), Vellore institute of technology, Vellore, on November 29th to 1st December 2019.

5. Participated and presented a paper entitled "Synthesis and characterization of Reduced Graphene Oxide by Cobalt oxide composite electrode" in 64th DAE Solid State Physics Symposium-2019 organized by the Bhabha Atomic Research Center, Mumbai, on December 18th to 22th 2019.

6. Participated in the "Conducting polymer Nanocomposites and its Application" organized by AMC Engineering College Bangalore, on July 15th 2020.

7. Participated in the "Recent Advancements is Thermal Analyzers for Materials Characterization" organized by Department of Physics, Gulbarga University Kalaburagi, on July 24th 2020.

8. Participated on the "Nanomaterial and Its energy Applications" organized by Department of Physics, BLDEA's S. Arts & K.C.P. science college Vijayapur, on November 2020.

9. Participated in the "Diversity and Inclusion–An Epitome of Unit (DIEU-21)"organized by Department of Physics, NIT, Tiruchirapalli, Tamil Nadu on June 25th, 2021.

10. Participated and presented a paper entitled "Optical and Morphological of Reduced Graphene Quantum Dots for Electrochemical Application" 2nd ICPN 2021 organized by Department of Physics at Mangalore University, on October 28th to 30th 2021.

11. Participated and presented a paper entitled "Structural, Morphological characterization of Nitric acid and Potassium hydroxide/Activated carbon composite" organized by Institute of Engineering Research 4th ICASETM-21 International Conference held at **Holiday Inn Bur Dubai, UEA.** During 29th to 30th December 2021.

Research Guide

Research Student
(Veeresh S)